

REMARKS

These remarks are in response to the non-final Office Action mailed October 23, 2002. Claim 124 has been canceled without prejudice to Applicants' right to prosecute the canceled subject matter in any divisional, continuation, continuation-in-part or other application. Claims 98, 104-105, 107-108, 112, 117-118, 120-121, 123, 126-128, 133, 139-140, 142-143, 148, and 152 have been amended. The amendments to the claims do not add new matter and are made to correct antecedent basis for certain claim terms and to further clarify the materials present in the sensors and sensor arrays of the invention.

Attached is a marked-up version of the changes being made by the current amendment.

I. OBJECTION OF CERTAIN CLAIMS UNDER 37 C.F.R. §1.75(c)

Claims 124 and 133 are objected to under 37 C.F.R. §1.75(c), as allegedly being improper for failing to limit the subject matter of a previous claims. Applicants have canceled claim 124, thus rendering the objection moot. Claim 133 has been amended to remove recitation of "compositionally different". Thus the claim does not include all possible combinations. Due to claim differentiation, the independent claim could be either compositionally the same or compositionally different sensors, the dependent claim 133 further limits the independent claim by reciting that the conductive organic material in the plurality of sensor is the same.

II. REJECTION UNDER 35 U.S.C. §112, FIRST PARAGRAPH

Claims 98-99, 101, 104-105, 108-110, 112, 114-118, 120-122, 124, 128-134, 136-140, 143-147, and 152-158 stand rejected under 35 U.S.C. §112, first paragraph, as allegedly containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 124 has been canceled, thus the rejection is moot with respect to this claim. Applicants respectfully traverse with respect to the claims as amended.

The claims have been amended to remove recitation of semiconductors. Claims 117-118 and 139-140 have been amended to correct the dependency and recitation of "carbon black".

Applicants believe that the rejection is overcome. Accordingly, Applicants respectfully request withdrawal of the §112, first paragraph rejection.

III. REJECTION UNDER 35 U.S.C. §112, SECOND PARAGRAPH

Claims 112, 121, 123, and 143 stand rejected under 35 U.S.C. §112, second paragraph as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Applicants respectfully traverse with respect to the amended claims.

Claim 112 has been amended to include a comparative basis for the comparative phrase. In addition, new claim 159 has been added to further include a plurality of sensor having the described sensor characteristics.

Claims 121 and 143 have been amended to correct antecedent basis.

Claims 108 and 128 have been amended to recite "metal oxide" thereby correcting antecedent basis for this term.

Claim 159 has been added and claim 123 has been amended to depend from claim 159.

Applicants believe that the foregoing amendments and remarks overcome the rejections. Accordingly, Applicants respectfully request withdrawal of the \$112, second paragraph rejection.

IV. REJECTION UNDER 35 U.S.C. §103

Claims 98-110, 112-124, and 126-158 stand rejected under 35 U.S.C. §103 as allegedly being unpatentable over Gibson in view of Casella, deLacy Costello, Thackeray, Yamato, Galal, Naarmann, Li (Materials Research Society Symposium Proceedings, 1995), Sakaguchi, Sestak, Torsi or Wampler and Breheret, Mifsud (both USP 5,801,297 and WO 95/08113), Moy or Persaud (WO 86/01599).

Applicants would like to first point out a fundamental difference between "electrochemical sensors" and the sensors of the claimed invention. Applicants respectfully direct that Examiner to Exhibits A and B which illustrates a fundamental difference between a number of the cited "electrochemical sensors" and the sensors of the invention. As will be noted in Exhibit A, an electrochemical sensor requires additional electrodes immersed in a liquid electrolyte. Each electrode is attached to a circuit using a single conductive lead. The electrons involved in the electrochemical reaction flow from the working electrode through the external circuit, producing the output signal of the sensor. An analyte is contacted with, for

example, an aqueous buffer that is in contact with a sensor and an analyte does not initially come into direct contact with the sensor. The sensors of the electrochemical systems undergo an oxidation or reduction thereby changing electron flow through the system between the a cathode electrode and an anode electrode.

In contrast, Exhibit B shows how a sensor of the invention works. A sensor of the invention works by measuring a change in resistance across the sensor material comprising two conductive leads with a sensing area between the leads. A change in the resistance of the sensor occurs between the conductive leads when contacted by an analyte. The sensors of the invention do not require additional electrodes. Rather the analyte directly contacts and interacts with the sensors of the invention causing, for example, a change in resistance across the sensor material. With this fundamental difference being presented a number of cited references can easily be removed in the present rejections.

The following cited references teach "electrochemical sensors" such as those in Exhibit A, which are fundamentally different in operation and composition than the sensors of the claimed invention.

- Casella teaches a sensor layered with polyaniline. The Casella sensor measurements are done using an electrochemical system such as that presented in Exhibit A. For example, Casella teaches at page 218, §2.2 "Apparatus", that "[c]yclic voltammetry (CV) was done in a three-electrode cell using a Cu-PANI working electrode, a saturated colomel reference electrode (SCE) . . . and a platinum foil counter electrode." As such the Casella

sensor has only a single conductive lead and measures redox reactions upon the sensor material.

- Thackeray et al. is electrochemical in nature, requiring an aqueous media containing ions to maintain a potential on the sensor. The electrochemical reaction involves a transfer of faradic charge and associated ions between the sensor of Thackeray et al. and the phase containing the analyte to be sensed. Thus, a vapor is not in direct contact with the sensor of Thackeray et al. The sensors of Thackeray et al. measure a change in redox at the sensor interface with the aqueous medium. Thackeray et al. does not measure a change in resistance.

- Yamato et al. teaches a sensor for electrochemical measurements. The sensor material of Yamato et al. is utilized in a "three-electrode cell containing 5 ml of 0.1 M KCl/0.1 M phosphate buffer (PB, pH 7.5) solution." (see page 232, §2.4 "Measurements"). As such the Yamato et al. sensor has only a single conductive lead and measures a change in redox at the sensor interface with the aqueous medium.

- Galal utilizes an electrochemical sensor system (i.e., "three electrodes, Pt, PMT, and PMT/Fc"; see page 9, col. 1, lines 12-13). For example, in the sensor system of Galal 0.1 M H₂SO₄ and phosphate buffer, pH 6.7, were used (see, e.g., page 9, col. 2, lines 15-16). Thus, a vapor analyte was not in direct contact with the sensor. In addition, the sensors of Galal only require a standard single conductive lead, characteristic of electrochemical systems.

- Naarmann also teaches electrochemical systems. For example, Naarmann teaches that the electrochemical polymer material can be used as an electrode or electrodes in electrochemical storage cells (see English Abstract).
- Li (Materials Research Society Symposium Proceedings, 1995) also teaches electrochemical sensors (i.e., sensor that comprise a single conductive lead). For example, at page 583-584, Li shows the use of a PANI-Pd film as an electrode (e.g. a cathode/anode) in an electrochemical cell. Li does not teach or suggest a sensor comprising two conductive leads that undergo a measurable change due to adsorption or absorption of an analyte.

Applicants respectfully submit that Casella, Thackeray, Yamato, Galal, Naarmann, and Li are fundamentally different sensor systems and one of skill in the art would not look to these sensor systems in developing a chemoresistive-type sensors. In fact, Sestak (cited in the present Office Action) actually teaches away from electrochemical sensors:

Conducting polymer-based sensors utilize electrochemical methods for detection, wherein the polymer acts as an electrode, or alternatively, they are based on simple resitometric detection. *The former can have the disadvantage of poor stability due to polymer degradation, usually caused by over-oxidation occurring during electrochemical cycling.*

(See page 118, 2nd full paragraph under the "Introduction"; emphasis added).

Applicants' claimed invention does not require such a charger transfer system and thus can sense analytes that the electrochemical approach cannot, and can do so in contact with liquids or other ambients like gases that do not support electrochemical reactions. Thus, because of the fundamentally

different measurements and reactivity of the two different types of sensors one of skill in the art would not expect materials found in electrochemical systems to be capable of adsorbing and/or absorbing analytes to provide a measureable change between two conductive leads separated by the sensing area. Accordingly, one of skill in the art would not combine the electrochemical sensor references with those teaching chemoresistive-type sensors.

Turning now to the cited references and combinations, the Office Action indicates that Gibson is no longer anticipatory of Applicants' claimed invention (see the Office Action at page 12, paragraph 8). Gibson, as the primary reference, admittedly does not teach or suggest a composition in which the two conductive materials are mixed together to form a single sensing material or as an array having sensors that are not organic polymer based (see the Office Action at page 4, lines 16-19). In addition, Gibson does not teach or suggest the element of:

wherein the compositionally different conductive material is selected from the group consisting of an organic conductor, an organic complex, an inorganic conductor and a mixed inorganic/organic conductor, wherein the inorganic conductor is a metal, a metal alloy, a metal oxide, [a doped semi-conductor,] or a superconductor, or a combination thereof and wherein the inorganic conductor has an electrical conductivity that decreases as the temperature increases

as recited in Applicants' claims 98, 104, 105, 108, 126, 128, and 152. Furthermore, although the Office Action construes "two monomers" as being two conductive materials (see Office Action at pg. 4, lines 10-12) such monomers are not "compositionally different" materials as recited in Applicants' claims.

The secondary references (e.g., Casella, deLacy Costello, Thackeray, Yamato, Galal, Naarmann, Li (Materials Research Society Symposium Proceedings, 1995), Sakaguchi, Sestak, Torsi,

Wampler, Breheret, Mifsud (both USP 5,801,297 and WO 95/08113), Moy, or Persaud (WO 86/01599)) are applied in combination with Gibson for the alleged teaching or suggestion that the secondary references show that the claimed composites are known as gas sensors or would have been expected to form a sensing material that would have enhanced properties relative to the conducting polymers used by Gibson (see page 12, paragraph 8 of the Office Action). Applicants respectfully traverse the rejections based upon the combination of Gibson with any of the secondary references.

Applicants respectfully submit 1) that there is no suggestion or motivation to combine the references particularly where the references teach electrochemical sensors, 2) that the combination fails to teach or suggest each and every element found in Applicants' claimed invention, and 3) that there is no teaching or suggestion in the references or in the art that Applicants' claimed invention would have the unexpected results as stated in the prior responses, which are reiterated herein below.

Gibson admittedly does not teach or suggest Applicants' claimed invention. Casella is combined with Gibson to overcome the deficiencies of Gibson. However, Casella does not remedy the deficiencies of Gibson and thus does not render the present invention obvious. For example, Casella teaches that the copper particles are "deposited onto" the polyaniline films of Casella (see page 219, first column, 6 lines from the bottom; page 220, second column, lines 1-3; page 221, column 1, lines 1-4). Thus, the combination of Gibson and Casella teach and suggest a layering of materials and not the single sensing material between two electrodes as recited in Applicants' claims.

The Office Action alleges that the Casella reference teaches "from the title" that the copper particles are dispersed into the polyaniline films. Applicants respectfully disagree based upon the repeated teachings found in the reference, however, even if the copper particles are dispersed "into" the polyaniline film, which they are not, the Casella reference teaches only a single conductive lead. The Casella reference teaches an electrochemical sensor as described above. The electrochemical system described by Casella does not measure a change in resistance across the sensing area. Rather the Casella reference teaches a change electron flow between a cathode electrode and an anode electrode (one electrode being the Cu-PANI electrode). A change in electrons in the system is induced by adding an analyte to an aqueous phase in which the electrodes are submerged. Thus, the Casella reference does not teach two conductive leads. The electrode of Casella containing the copper/polyaniline absorbs or releases electrons thereby changing electron flow between the cathode and anode. There is no teaching or suggestion in either the Gibson or Casella reference of Applicants' claimed sensors comprising:

. . .alternating regions of a conductive organic material and a conductive material compositionally different than the conductive organic material disposed between, and in electrical communication with, the at least two conductive leads, wherein the sensing area provides an electrical path through the regions of the conductive organic material and the regions of the compositionally different conductive material. . .

Nor is there any teaching or suggestion that such a composition would be capable of adsorbing or absorbing an analyte and changing, for example, resistance between two conductive leads.

Applicants respectfully submit that because of the fundamentally different sensing methods used, one of skill in the art would not have looked to Casella to overcome the deficiencies of Gibson. Even if the two are combined the combination fails to teach each and every element of Applicants' claimed invention. The combination of Gibson, which does not teach a single sensing area between two conductive leads, is combined with Casella, which also does not teach a single sensing area comprising a composite between two conductive leads. Accordingly, the combination fails to teach or suggest each and every element of Applicants' claimed invention.

Gibson is also combined with de Lacy Costello. This combination of references also fails to teach each and every element of Applicants' claimed invention. The Office Action alleges that because of the \$112, first paragraph rejections above (i.e., the temperature/conductivity characteristics), the de Lacy Costello reference is appropriate relative to the claimed devices. Applicants submit that the amendments and remarks above with respect to the \$112, first paragraph rejection render the application of the de Lacy Costello reference under \$103 moot. Accordingly, the rejection of Gibson in view of de Lacy Costello may be withdrawn.

Gibson is also combined with Thackeray et al. Thackeray et al. teach a polymer layer having disposed on the surface Pt catalyst. The polymer layer covers the electrodes such that the Pt catalyst layers are not between the electrodes but rather on the surface of the polymer layer (see, e.g., Scheme I and II pages 6674-6675 of Thackeray et al.). In addition, the

chemistry which produces a signal in Thackeray et al. is electrochemical in nature, requiring an aqueous media containing ions to maintain a potential on the sensor. The electrochemical reaction involves a transfer of faradic charge and associated ions between the sensor of Thackeray et al. and the phase containing the analyte to be sensed. Thus, a vapor is not in direct contact with the sensor of Thackeray et al. The Office Action at page 12, line 15, addresses Applicants' arguments by stating that "The Thackeray reference is clearly sensitive to gases - hydrogen and oxygen." However, the Thackeray et al. reference does not teach or suggest that an analyte is capable of adsorbing or absorbing to the sensor material. The Thackeray et al. references teaches that the sensor material of Thackeray et al. is sensitive to changes in electrons in the aqueous medium (i.e., oxidation or reduction due to the presence of hydrogen or oxygen).

Applicants' claimed invention does not require such a charger transfer system and thus can sense analytes that the electrochemical approach cannot, and can do so in contact with liquids or other ambients like gases that do not support electrochemical reactions. For example, claims 98, 104, 105, 108, 126, 127, 128, 148, and 152 recite that a vapor is in direct contact with the sensing area. This is in contrast to the sensor of Thackeray et al., which does not make direct contact with the medium comprising the analyte. In addition, Thackeray et al. do not teach or suggest polyaniline as recited in Claim 106.

Applicants respectfully submit that because of the fundamentally different sensing methods used in Thackeray et al. and Gibson, one of skill in the art would not have looked to

Thackeray et al. to overcome the deficiencies of Gibson. Even if the two are combined the combination fails to teach each and every element of Applicants' claimed invention. The combination of Gibson, which does not teach a single sensing area between two conductive leads, is combined with Thackeray, which also does not teach a single sensing area comprising a composite between two conductive leads. Accordingly, the combination fails to teach or suggest each and every element of Applicants' claimed invention. For at least the foregoing Gibson in combination with Thackeray et al. cannot render Applicants' claimed invention.

Gibson is also combined with Yamato et al. Yamato et al. teach sensors having on their surface glucose oxidase (GOD) (see, Yamato at page 235, first column, section 3.2). In addition, Yamato et al. teach a sensor for electrochemical measurements. The sensor material of Yamato et al. is utilized in a "three-electrode cell containing 5 ml of 0.1 M KCl/0.1 M phosphate buffer (PB, pH 7.5) solution." (See page 232, §2.4 "Measurements"). As such the Yamato et al. sensor has only a single conductive lead. Applicants respectfully submit that the teachings of Yamato are so removed from the presently claimed invention that one of skill in the art would not combine Yamato et al. with Gibson. Applicants submit that even if there were motivation to combine Gibson and Yamato, which there is not, at most the combination would teach the use of immobilized enzymes (very different than conductive materials) on a polymer material for use in an electrochemical system (e.g., having only a single conductive lead). Accordingly, the combination of Gibson and Yamato fail to teach or suggest each and every element of

Applicants' claimed invention. The combination of Gibson, which does not teach a single sensing area between two conductive leads, is combined with Yamato, which also does not teach a single sensing area comprising a composite between two conductive leads. Accordingly, the combination fails to teach or suggest each and every element of Applicants' claimed invention.

Gibson is further combined with Galal. Galal teaches ferrocene/ferrocenium and poly(3-methylthiophene). Galal utilizes an electrochemical sensor system (i.e., "three electrodes, Pt, PMT, and PMT/Fc"; see page 9, col. 1, lines 12-13). For example, in the sensor system of Galal 0.1 M H₂SO₄ and phosphate buffer, pH 6.7, were used (see, e.g., page 9, col. 2, lines 15-16). Thus, a vapor analyte was not in direct contact with the sensor. In addition, the sensors of Galal only require a standard single conductive lead, characteristic of electrochemical systems.

Applicants also respectfully submit that Galal is unavailable as prior art against the claimed invention. The Applicants respectfully direct the Examiner to the 37 C.F.R. §1.131 Declaration of Dr. Nathan S. Lewis (Exhibit C) and the accompany evidence attached as Exhibit D. The evidence shows the conception of the claimed invention and diligence from the time of conception to the time of filing of the provisional application, the conception being performed prior to the public availability of Galal (as evidenced by the date stamped cover of April 7, 1998; see Exhibit E). Accordingly, Galal is unavailable as prior art against the claimed invention.

Applicants respectfully submit that Galal is unavailable as prior art. However, even if it was available, because of the fundamentally different sensing methods used in Galal and Gibson, one of skill in the art would not have looked to Galal to overcome the deficiencies of Gibson. Even if the two are combined the combination fails to teach each and every element of Applicants' claimed invention. The combination of Gibson, which does not teach a single sensing area between two conductive leads, is combined with Galal, which also does not teach a single sensing area comprising a composite between two conductive leads. Accordingly, the combination fails to teach or suggest each and every element of Applicants' claimed invention. For at least the foregoing reasons Gibson in combination with Galal cannot render Applicants' claimed invention obvious under Section 103.

Gibson is also combined with Naarmann. Naarmann also teaches electrochemical systems. For example, Naarmann teaches that the electrochemical polymer material can be used as an electrode or as sensor electrodes in electrochemical storage cells (see English Abstract). In addition, neither Gibson nor Naarmann teach the markush group as recited above and found in claims 98, 104, 105, 108, 126, 128, and 152. Thus, the combination of Gibson and Naarmann do not anticipate Applicants' claimed invention in at least two ways: 1) neither reference teaches the markush group as recited above and therefore does not teach or suggest each and every element; and 2) because of the fundamentally different sensing methods used in Naarmann and Gibson, one of skill in the art would not have looked to Naarmann to overcome the deficiencies of Gibson. In addition,

the combination of Gibson, which does not teach a single sensing area between two conductive leads, is combined with Naarmann, which also does not teach a single sensing area comprising a composite between two conductive leads. Accordingly, the combination fails to teach or suggest each and every element of Applicants' claimed invention.

Gibson is also combined with Li (Materials Research Society Symposium Proceedings, 1995). Li also teaches electrochemical sensors (i.e., sensors that have a single conductive lead). For example, at page 583-584, Li shows the use of a PANI-Pd film as an electrode (e.g. a cathode/anode) in an electrochemical cell. Li does not teach or suggest a sensor comprising two conductive leads that undergo a measurable change due to adsorption or absorption of an analyte. Thus, the combination of Gibson and Li do not anticipate Applicants' claimed invention because one of skill in the art would not have looked to an electrochemical cell cathode or anode as the basis for developing a sensor comprising two conductive leads that undergoes a measurable change upon contact with an analyte. Because of the fundamentally different systems, one of skill in the art would not have looked to Li to overcome the deficiencies of Gibson. In addition, the combination of Gibson, which does not teach a single sensing area between two conductive leads, is combined with Li, which also does not teach a single sensing area comprising a composite between two conductive leads. Accordingly, the combination fails to teach or suggest each and every element of Applicants' claimed invention.

Gibson is further combined with Sakaguchi. Sakaguchi teaches "Gas Sensor Electrode Utilizing Electrode Reaction" (see, e.g., the title). An "electrode" has only one conductive lead and operates through redox reactions at the anode and cathode. As mentioned above, a reaction at an electrode of an electrochemical sensor does not change resistance upon contact with an analyte, rather the electrode undergoes an oxidation/reduction reaction, such a change is not, for example, a change in resistance. Because of the fundamentally different systems, one of skill in the art would not have looked to Li to overcome the deficiencies of Gibson. Furthermore, there is no teaching or suggestion in the combination of references that indicate the claimed compositions would be reactive with an analyte thereby changing electrical properties measured between to conductive leads.

Gibson is combined with Sestak. However, Applicants respectfully submit that Sestak is unavailable as prior art against the claimed invention. The Applicants respectfully direct the Examiner to the 37 C.F.R. §1.131 Declaration of Dr. Nathan S. Lewis (Exhibit C) and the accompany evidence attached as Exhibit D. The evidence shows the conception of the claimed invention and diligence from the time of conception to the time of filing the provisional application, the conception being performed prior to the public availability of Sestak et al. (i.e., November 1997 as evidenced by Exhibit F). Accordingly, Sestak et al. is unavailable as prior art against the claimed invention.

Gibson is also combined with Torsi et al. Applicants also respectfully submit that Torsi et al. is unavailable as prior art against the claimed invention. The Applicants respectfully direct the Examiner to the 37 C.F.R. §1.131 Declaration of Dr. Nathan S. Lewis (Exhibit C) and the accompany evidence attached as Exhibit D. The evidence shows the conception of the claimed invention and diligence from the time of conception to the time of filing of the provisional application, the conception being performed prior to the public availability of Torsi et al. (as evidenced by the date stamped cover of July 14, 1998; see Exhibit G). Accordingly, Torsi et al. is unavailable as prior art against the claimed invention.

Gibson is further combined with Wampler. Wampler teaches the use of a polypyrrole-carbon black composites for eliminating Cr(VI) in the environment by reducing Cr(VI) to Cr(III) (see, e.g., page 1820, "E. Use of polypyrrole carbon-black composites for environmental remediation of Cr(VI)"). Wampler, however, does not teach or suggest the usefulness of polypyrrole/carbon-black composites as chemoresistive-type sensors comprising two electrical leads that measure a change in the electrical properties of the composite between the two leads when contacted with an analyte. Thus, the combination of Gibson, which does not teach a single sensing area between two conductive leads, is combined with Wampler, which also does not teach a single sensing area comprising a composite between two conductive leads. Accordingly, the combination fails to teach or suggest each and every element of Applicants' claimed invention.

Gibson is also combined with Breheret. Breheret mentions two different types of sensors: 1) semiconductor gas sensors, and 2) conducting polymer sensors. Neither of the two types of sensors is described nor does Breheret teach or suggest the composition of the sensors. The only description found in the Breheret reference is to the "AROMASCAN A20S Device".

Applicants respectfully submit that the Breheret reference is not enabled for any teaching relied upon by the Examiner to render Applicants' invention obvious. However, even if the Breheret reference was enabled, Breheret teaches away from Applicants' claimed invention due to the teaching that such polymer films are less sensitive than semiconductive gas sensors. This is in contrast to the unexpected finding presented in Applicants' disclosures which teaches that the conductive organic polymers and compositionally different conductive material composites have orders of magnitude better sensitivity than other conventional polymer composites to amine analytes. Accordingly, the combination of Gibson and Breheret fails to teach or suggest each and every element of Applicants' claimed invention.

Gibson is further combined with Mifsud (both USP 5,801,297 and WO 95/08113). Applicants respectfully submit that Mifsud fails for the same reasoning as presented for Breheret above. The Mifsud reference does not enable the polymer sensors (i.e., there is no teaching or suggestion as to the composition of such polymer sensors). The only teaching that would allow a person skilled in the art to have the faintest idea as to the composition of the conductive polymer sensors is found at column 1, lines 53-64, which teaches that the conductive polymer

sensors "have a film made of a conductive polymer sensitive to the molecules of odorous substances." Mifsud fails to teach or suggest a sensing area of a conductive organic polymer and a compositionally different conductive material.

Gibson is combined with Moy. Applicants' claimed invention is further rejected as allegedly obvious over Gibson in view of Moy. Applicants respectfully submit that Moy fails for the same reasoning as presented for Breheret and Mifsud above. The Moy reference does not enable the polymer sensors (i.e., there is no teaching or suggestion as to the composition of such polymer sensors). Moy teaches at most an array of (1) metal oxide gas sensors and (2) sensors having a conductive polymer. Moy does not teach or suggest a sensor comprising a material having both a conductive organic material and a compositionally different conductive material. Nor does Moy teach or suggest an array of sensors, wherein at least one sensor comprises a material having both a conductive organic material and a compositionally different conductive material. Thus, the combination of Gibson and Moy does not teach or suggest Applicants' claimed invention.

Gibson is further combined with Persaud (WO 86/01599). Applicants' claimed invention is further rejected as allegedly obvious over Gibson in view of Persaud. Applicants respectfully submit that Persaud fails for the same reasoning as presented for Breheret, Mifsud, and Moy, above. Persaud teaches as most a sensor having an organic polymeric semiconductor such as polyindole (see, e.g., page 4, line 2). Persaud does not teach or suggest a sensor having a sensing area comprised of a combination of a conductive organic material and a

compositionally different conductive material. Nor does Persaud teach or suggest an array of sensor, wherein at least one sensor comprises a material having both a conductive organic material and a compositionally different conductive material. Thus, the combination of Gibson and Moy does not teach or suggest Applicants' claimed invention.

Applicant asks that all claims be allowed. Enclosed is a check in the amount of \$110.00 for the Petition for Extension of Time for One Month fee. Please apply any other charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

Date: 2/24/03



Joseph R. Baker, Jr.
Reg. No. 40,900

Fish & Richardson P.C.
PTO CUSTOMER NO. 20985
4350 La Jolla Village Drive, Suite 500
San Diego, California 92122
Telephone: (858) 678-5070
Facsimile: (858) 678-5099

Version with markings to show changes made

In the claims:

Claim 124 has been cancelled.

Claims 98, 104, 105, 107, 108, 112, 117, 118, 120, 121, 123, 126-128, 133, 139, 140, 142, 143, 148, and 152 have been amended as follows:

98. (Twice Amended) A sensor, comprising:

at least two conductive leads;

a sensing area comprising alternating regions of a conductive organic material and a conductive material compositionally different than the conductive organic material disposed between, and in electrical communication with, the at least two conductive leads, wherein the sensing area provides an electrical path through the regions of the conductive organic material and the regions of the compositionally different conductive material, and wherein the sensing area is in direct contact with a vapor comprising an analyte to be detected, wherein the compositionally different conductive material is selected from the group consisting of an inorganic conductor, a carbon black, and a mixed inorganic/organic conductor, wherein the inorganic conductor is a metal, a metal alloy, a metal oxide, [a doped semi-conductor,] a superconductor, or a combination thereof and wherein the inorganic conductor has an electrical conductivity that decreases as the temperature increases; and

an apparatus in electrical communication with the conductive leads for detecting a change in the sensing area between the at least two conductive leads when contacted with an analyte.

104. (Twice Amended) A sensor, comprising:
at least two conductive leads;

a sensing area comprising alternating interpenetrating regions of a conductive organic material and a conductive material compositionally different than the conductive organic material disposed between and in electrical communication with the at least two conductive leads, wherein the sensing area provides an electrical path through the regions of the conductive organic material and the regions of the compositionally different conductive material, and wherein the sensing area is in direct contact with a vapor comprising an analyte to be detected, wherein the compositionally different conductive material is selected from the group consisting of an organic conductor, an organic complex, an inorganic conductor and a mixed inorganic/organic conductor, wherein the inorganic conductor is a metal, a metal alloy, a metal oxide, [a doped semi-conductor,] or a superconductor, or a combination thereof and wherein the inorganic conductor has an electrical conductivity that decreases as the temperature increases; and

an apparatus in electrical communication with the conductive leads for detecting a change in the sensing area between the at least two conductive leads when contacted with an analyte.

105. (Twice Amended) A sensor, comprising:

at least two conductive leads;

a sensing area comprising dispersed regions of a conductive organic material and a conductive material compositionally different than the conductive organic material wherein the dispersed regions provide interpenetrating regions of the conductive organic material and a conductive material compositionally different than the conductive organic material, the sensing area disposed between and in electrical communication with the at least two conductive leads, wherein the sensing area provides an electrical path through the regions of the conductive organic material and the regions of the compositionally different conductive material, and wherein the sensing area is in direct contact with a vapor comprising an analyte to be detected, wherein the compositionally different conductive material is selected from the group consisting of an organic conductor, an organic complex, an inorganic conductor and a mixed inorganic/organic conductor, wherein the inorganic conductor is a metal, a metal alloy, a metal oxide, [a doped semi-conductor,] or a superconductor, or a combination thereof and wherein the inorganic conductor has an electrical conductivity that decreases as the temperature increases; and

an apparatus in electrical communication with the conductive leads for detecting a change in the sensing area between the at least two conductive leads when contacted with an analyte.

107. (Twice Amended) The sensor of claim 106, wherein the conductive material compositionally different than the polyaniline or emeraldine salt of polyaniline is selected from the group consisting of an organic conductor, an organic complex, an inorganic conductor, and a mixed inorganic/organic conductor, wherein the inorganic conductor is a metal, a metal alloy, a metal oxide, [a doped semi-conductor,] an oxidized metal, a superconductor, and any combination thereof.

108. (Twice Amended) A sensor array comprising:
a plurality of sensors, wherein at least one sensor comprises:

at least two conductive leads;

a sensing area comprising alternating interpenetrating regions of a conductive organic material and a conductive material compositionally different than the conductive organic material disposed between and in electrical communication with the at least two conductive leads, wherein the sensing area provides an electrical path through the alternating interpenetrating regions of the conductive organic material and the regions of the compositionally different conductive material, wherein the sensing area is in direct contact with a vapor comprising an analyte to be detected, wherein the compositionally different conductive material is selected from the group consisting of an organic conductor, an organic complex, an inorganic conductor and a mixed inorganic/organic conductor, wherein the inorganic conductor is a metal, a metal alloy, a metal oxide, [a doped semi-conductor,] or a superconductor, or a combination thereof and wherein the

inorganic conductor has an electrical conductivity that decreases as the temperature increases.

112. (Amended) The sensor array according to claim [108] 159, wherein the conductive organic material of [the at least] one sensor of the plurality of sensors is compositionally [the same or compositionally] different than at least one other sensor of the plurality of sensors.

117. (Twice Amended) The sensor array according to claim 110, wherein the inorganic conductor is selected from the group consisting of Ag, Au, Cu, Pt[, carbon black], and AuCu.

118. (Amended) The sensor array according to claim [110] 108, wherein the [inorganic conductor] compositionally different conductive material is carbon black.

120. (Amended) The sensor array according to claim 108, wherein the conductive material compositionally different than the conductive organic material is a member selected from the group consisting of an organic conductor, an inorganic conductor, and a mixed inorganic[-]/organic conductor.

121. (Amended) The sensor array according to claim 108, wherein the conductive material compositionally different than the conductive organic material is a member selected from the group consisting of a metal, a metal alloy, a metal oxide, an organic complex, [a semiconductor,] a superconductor, and a mixed inorganic[-]/organic [complex] conductor.

123. (Amended) The sensor array according to claim [108] 159, wherein the compositionally different conductive material of each of the sensors in the plurality of sensors comprises a conductive organic material.

126. (Twice Amended) A sensor array comprising:
a plurality of sensors, wherein at least one sensor comprises:

at least two conductive leads;

a sensing area comprising alternating interpenetrating regions of a conductive organic material and a conductive material compositionally different than the conductive organic material disposed between, and in electrical communication with, the at least two conductive leads, wherein the sensing area provides an electrical path through the regions of the conductive organic material and the regions of the compositionally different conductive material, wherein the sensing area is in direct contact with a vapor comprising an analyte to be detected, wherein the compositionally different conductive material is selected from the group consisting of an organic conductor, an organic complex, an[d] inorganic conductor, and a mixed inorganic/organic conductor, wherein the inorganic conductor is a metal having electrical conductivity that decreases as the temperature increases, a metal alloy, a metal oxide, [a doped semi-conductor,] or a superconductor, or a combination thereof; and

a measuring apparatus electrically coupled to the at least two conductive leads for detecting a change in the sensing area when contacted with an analyte.

127. (Amended) A sensor array comprising:

a plurality of sensors wherein at least one sensor comprises alternating interpenetrating regions of a conductive organic material and regions of a compositionally different conductive material wherein the sensors are in direct contact with a vapor comprising an analyte to be detected; and

means, electrically coupled to the plurality of sensors, for detecting a change in the plurality of sensors when contacted with an analyte.

128. (Twice Amended) A sensor array system comprising:

a plurality of sensors, wherein at least one sensor comprises:

at least two conductive leads;

a sensing area comprising alternating interpenetrating regions of a conductive organic material and a conductive material compositionally different than the conductive organic material disposed between and in electrical communication with the at least two conductive leads, wherein the sensing area provides an electrical path through the regions of the conductive organic material and the regions of the compositionally different conductive material, wherein the sensing area is in direct contact with a vapor comprising an analyte to be detected, wherein the compositionally different conductive material is selected from the group consisting of an organic conductor, an organic complex, an inorganic conductor and a mixed inorganic/organic conductor, wherein the inorganic conductor is a metal, a metal alloy, a metal oxide, [a doped semi-conductor,] or a superconductor, or a combination thereof

and wherein the inorganic conductor has an electrical conductivity that decreases as the temperature increases;

a measuring apparatus that detects a change in the electrical properties of the at least one sensor, wherein the at least one sensor is in communication with the measuring apparatus; and

a computer comprising a resident algorithm, wherein the computer processes the change in the electrical properties.

133. (Amended) The sensor array system according to claim 131, wherein the conductive organic material of the plurality of sensors are compositionally the same [or compositionally different].

139. (Amended) The sensor array system according to claim 130, wherein the inorganic conductor is a member selected from the group consisting of Ag, Au, Cu, Pt[, carbon black], and AuCu.

140. (Amended) The sensor array system according to claim [130] 128, wherein the compositionally different conductive material [inorganic conductor] is carbon black.

142. (Twice Amended) The sensor array system according to claim 128, wherein the conductive material compositionally different than the conductive organic material is selected from the group consisting of an organic conductor, an inorganic conductor, and a mixed inorganic[-]/organic conductor.

143. (Twice Amended) The sensor array system according to claim 128, wherein the conductive material compositionally different than the conductive organic material is selected from the group consisting of a metal, a metal alloy, a metal oxide, an organic complex, [a semiconductor,] a superconductor, and a mixed inorganic[-]/organic [complex] conductor.

148. (Amended) A system for identifying a microorganism, the system comprising:

a measuring apparatus;

a sensor array comprising a plurality of sensors in communication with the measuring apparatus, wherein at least one sensor comprises:

at least two conductive leads;

a sensing area comprising alternating regions of a conductive organic material and a conductive material compositionally different than the conductive organic material disposed between and in electrical communication with the at least two conductive leads, wherein the sensing area provides an electrical path through the regions of the conductive organic material and the regions of the compositionally different conductive material, and wherein the sensing area is in direct contact with a vapor comprising a biomarker to be detected; and

a computer comprising a resident algorithm;

wherein the measuring apparatus is capable of detecting a response from each sensor in the array wherein the responses are indicative of the presence of a biomarker of a microorganism and the computer is capable of assembling the responses into a response profile whereby the computer associates the response

profile indicative of the biomarker with a microorganism for microorganism identification.

152. (Twice Amended) A system for detecting an analyte in a sample, comprising:

a substrate having a plurality of sensors wherein at least one sensor comprises:

at least two conductive leads;

a sensing area comprising alternating interpenetrating regions of a conductive organic material and a conductive material compositionally different than the conductive organic material disposed between, and in electrical communication with, the at least two conductive leads, wherein the sensing area provides an electrical path through the regions of the conductive organic material and the regions of the compositionally different conductive material such that the at least one sensor provides a response that varies according to the presence of an analyte in contact with it, , wherein the sensing area is in direct contact with a vapor comprising an analyte to be detected, wherein the compositionally different conductive material is selected from the group consisting of an organic conductor, an organic complex, an inorganic conductor and a mixed inorganic/organic conductor, wherein the inorganic conductor is a metal, a metal alloy, a metal oxide, [a doped semi-conductor,] or a superconductor, or a combination thereof and wherein the inorganic conductor has an electrical conductivity that decreases as the temperature increases;

a detector operatively associated with the plurality of sensors, for measuring the response of the plurality of sensors when contacted with the sample;

a sample delivery unit for delivering the sample to be tested to the plurality of sensors; and

an information storage and processing device configured to store an ideal response for a predetermined analyte and to compare the response of the plurality of sensors with the stored ideal response, to detect the presence of the analyte in the sample.

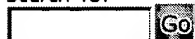


TSI Incorporated

[TSI homepage](#)[All TSI products](#)[Search TSI](#)**Combustion Menu**

[Combustion Home](#)
[Products](#)
[Application Notes](#)
[FAQs](#)
[Downloads](#)
[Links](#)
[Reps/Distributors](#)
[What's New](#)
[Calendar](#)
[Product Registration](#)
[Contact Us](#)
[Service](#)

Search TSI

☐ Include PDF Files

Combustion Analysis

Application Notes

Location: [TSI Home](#) > [Combustion Home](#) > [Application Notes](#)

The Theory Behind Electrochemical Sensors

Application Note TI-132

Many TSI instruments use electrochemical sensor technology. This Application Note is aimed to help you better understand the theory behind this technology. Since electrochemical sensors work with the same theory but different materials, we have described only how the CO sensor works in this Application Note.

The carbon monoxide sensor consists of three electrodes immersed in a liquid electrolyte (a non-metallic liquid that conducts electricity, usually through acids or dissolved salts). The three electrodes are the working electrode, the reference electrode, and the counter electrode. The most important of these is the working electrode (WE). The working electrode is made of platinum, which is a catalytic metal to CO (it catalyzes the oxidation of CO to CO₂), backed by a gas-permeable but hydrophobic (water-proof) membrane. The CO gas diffuses through the porous membrane and is electrochemically oxidized (Equation 1).

(Platinum catalyzes)



Equation 1: Chemical Reaction

The electrons involved in the electrochemical reaction flow from the working electrode through the external circuit, producing the output signal of the sensor. In order for the reaction to take place, the thermodynamic potential of the working electrode is of critical importance. The reference electrode (RE) provides a stable electrochemical potential in the electrolyte. The reference electrode is protected from exposure to the CO gas, so that its thermodynamic potential is always the same and remains constant. Also, no current is allowed to flow through the reference electrode (this would change the thermodynamic potential.) A counter-electrode (CE) is provided to complete the circuit of the electrochemical cell. The counter electrode functions solely as the second half-cell, and allows electrons to enter or leave the electrolyte.

The circuit that controls the potential of the working electrode and converts the signal current to a voltage is called a potentiostat. A simplified diagram of the sensor and potentiostat is illustrated below. The signal (current) from the working electrode (WE) is converted to a voltage by operational amplifier U2. This circuit also maintains the voltage of the working electrode at the bias potential, V_{bias}. The reference electrode (RE) potential is compared to the stable input voltage, V_{bias}. The op-amp U1 generates a voltage at the counter electrode (CE) which is just sufficient to produce a current that is exactly equal and opposite to the working electrode current. At the same time, a constant voltage is maintained between the reference electrode and working electrode.

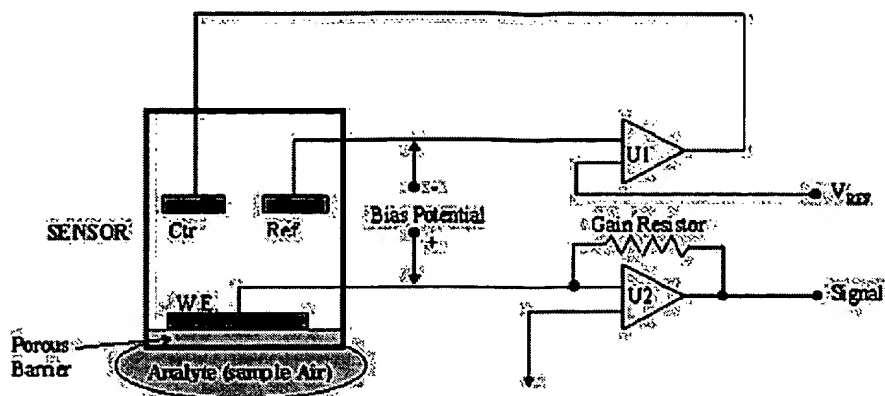


Figure 1. Schematic of Electrochemical Sensor and Circuit

The CO sensor is also equipped with a chemically selective filter. This filter removes potentially interfering gases before they reach the working electrode. With the filter operating properly the sensor will have minimal response to interfering gases.

The technology described above can be modified to give sensors that will respond to the different gases of interest. This can be accomplished by using different working electrodes, bias potentials, and chemically selective filters. The following Table shows which catalysts are used for each gas.

Table 1: Examples of gases and their catalysts

Gas analyzed	Electrocatalyst
NO ₂	Au
CO	Pt
H ₂	Au
NO	Au
O ₂	Au, Ag, Pt
SO ₂	Au
H ₂ S	Au



top



Combustion Analysis Homepage

For customer service, contact TSI directly.
©2003 TSI Incorporated. All rights reserved.

[\[Products\]](#) [\[Application Notes\]](#) [\[FAQ\]](#) [\[Downloads\]](#) [\[Links\]](#) [\[Representatives\]](#)
[\[What's New\]](#) [\[Calendar\]](#) [\[Product Registration\]](#) [\[Contact Us\]](#) [\[Service\]](#)

[\[Combustion Home\]](#) [\[TSI Home\]](#)

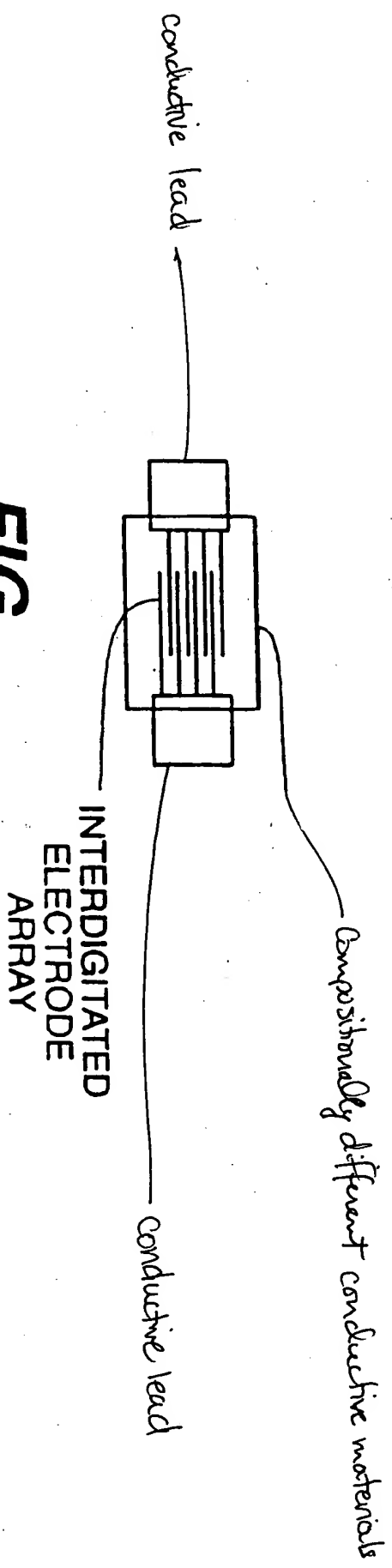


FIG.